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ASTEROPHILA, A NEW GENUS OF PARASITIC GASTROPODS.¹

JOSEPHINE RANDALL AND HAROLD HEATH.

During the dredging operations of the U. S. F. C. Str. *Albatross* in the vicinity of Japan (summer of 1906) four specimens of a starfish, *Pedicellaster* sp., were taken that had been parasitized by a new genus of gastropods. All were dredged in the sea of Japan off the coast of Corea at depths ranging from 150 fms. (sta. 4,867) to 163 fms. (sta. 4,861). In one host three parasites occurred, while only one was present in each of the other three, but in any event they occupied the coelom in the arm, and were attached by connective tissue strands to the body wall in the vicinity of the ambulacral ridge. As noted more particularly hereafter, this species is not put in communication with the exterior, the mouth and reproductive openings communicating with the body cavity of the host. During the time that the brood pouch is crowded with embryos the pseudopallium becomes accordingly considerably distended and tense, resulting in the inflation and consequent thinning of the body wall of the host along the dorsal side of the arm (Pl. II., Fig. 2). Under such circumstances it is possible that the body wall of the starfish finally ruptures, causing a diminution of the pressure on the pseudopallium which therefore discharges the embryos into the surrounding medium. After this process the break in the body wall is probably repaired, as there are evidences that one of the larger individuals has recently discharged its brood though there are no signs of a rent in the starfish arm.

In every case the body resembles in form a kidney or thick-set bean, and varies in size from two to twenty millimeters, this last extreme being due to some extent to the large number of embryos and the fluid in which they float. The ovary and the embryos themselves are light yellow in color due to the presence of yolk,

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the liver is of a light brownish shade while the other organs are unpigmented and more or less translucent, especially in the case of the pseudopallium that in life is so thin and transparent that the form and movements of the larvæ may be readily observed. As may be seen in Pl. I., Fig. 1, there are two openings into the body, one the mouth, corresponding in position to the hilum of a bean while the reproductive opening is placed laterally upwards of thirty degrees.

From various features of its organization it is readily possible to orient this animal and discover the axes of the body. As in several other parasitic gastropods the body is surrounded by a pseudopallium that appears to be a development of the snout or adjacent regions of the body. Growing upward it has enveloped the body completely save at one point, the reproductive and excretory pore. Considering the body proper, the foot is seen to exist in the form of a small though broad wedge-shaped fold (Pl. I., Fig. 1, *f*) covered with epithelium of greater thickness than that surrounding the body generally. In sections (Pl. II., Fig. 4, *f*) it is a fairly conspicuous object owing to its affinity for stains. Again, well-defined pedal ganglia and otocysts, located in close proximity to the foot and cerebral ganglia on the opposite side of the digestive tract, demonstrate the fact that the antero-posterior axis is the shorter of the roughly ellipsoid body, and that the transverse axis is accordingly the longer.

In this species the degenerative processes have advanced to a stage where the mantle and mantle cavity have largely disappeared, and yet, though rudimentary, they maintain their typical relations. Since the mantle fold is comparatively narrow (Pl. I., Figs. 1, 2, *g*) the cavity is accordingly shallow, as the mantle is closely applied to the visceral mass; nevertheless the epithelial cells bounding the cavity are not only higher than those elsewhere covering the body but they stain more intensely and are ciliated. On the left-hand side of the body the mantle border thickens considerably, and forms a projecting ridge that continues until the pallial cavity itself disappears. In the smallest specimen the mantle and cavity are relatively larger and the mantle fold is much more glandular, the gland cells being large and conspicuous.

As noted in a preceding paragraph, the mouth opening is borne on the summit of a low papilla in the mid line. In entire specimens it is further distinguished from the opening into the pseudopallium by occupying the center of a whitish area, upwards of 3 mm. in diameter in the largest specimens, caused by the compact feltwork of circular and radiating muscles enveloping what probably corresponds to the buccal tube. In the immediate neighborhood of the mouth opening the canal is comparatively slender, 0.28 mm. in diameter in large individuals, and is provided with a lining of simple columnar cells whose distal portions contain small quantities of a faintly staining, vacuolated secretion. Behind this point large numbers of small, irregularly distributed pyriform gland cells appear imbedded in the muscular meshwork surrounding the digestive tract, and their darkly staining ductules may be traced to intercellular openings in the buccal or pharyngeal epithelium, whose extent is increased by two symmetrically placed diverticula with short, stubby branches (Pl. I., Fig. 2) extending a short distance into the surrounding muscle sheath. These paired glands probably correspond to the ventral salivary glands of other molluscs as the buccal ganglia, connected by a commissure, are located in their vicinity.

No trace of a radula exists.

The buccal-pharyngeal tube with its enveloping glands and muscles, is relatively short, probably not over 1 mm. in length, but it spans a well defined head cavity (Pl. II., Fig. 3), which is a portion of the hæmocele as in other molluscs. Curving gently toward the ventral side of the body the tube leaves the sinus, and now devoid of gland cells and with a comparatively thin sheath of longitudinal and circular muscles, it passes back a short distance into the body and unites with the main portion of the digestive tract (*l*), a spacious cavity, lined with glandular epithelium, occupying most of the visceral mass not held by the gonad and its duct.

The pericardial cavity (Pl. I., Fig. 2) is situated on the anterior surface of the visceral mass on the right side. The contained heart consists of a single auricle and ventricle, both of large size and highly muscular. The first-named receives the blood from a broad sinus, which on one hand passes from the liver surface

and the neighborhood of the accessory reproductive glands in the ventral part of the visceral mass, and by means of another smaller branch takes the blood from the kidney. The aorta is very short and leads directly into what may be termed the head cavity, the large space surrounding the pharynx. From here numerous branches extend into the pseudopallium, liver and between the ovarian follicles. Of these the ones passing through the pseudopallium probably function in the interchange of gases as there are no traces of ctenidia or branchia.

One nephridium (Pl. I., Fig. 2, *n*) is present in the form of a greatly compressed sac covering the anterior surface of the visceral mass on the right-hand side. Its inner walls are often provided with lamellæ or folds, of varying size, projecting into the central lumen. The cells throughout are highly vacuolated and contain varying quantities of some granular secretion that in some locations present the form of concretions. We have been unable to definitely locate any clearly defined reno-pericardial opening. As shown in Pl. II., Fig. 6, *n*, the kidney invests the dorsal pericardial wall but there are, so far as we have seen, no modified cells indicating a nephrostome. The external pore (Pl. I., Fig. 2, *e'*) is situated on the anterior face of the visceral mass immediately below the margin of the mantle.

While the ganglia are fairly well defined and distinct the nerve fibers resemble so closely the connective tissue and muscle bundles through which they make their way that it is very difficult to determine their course. The cerebral (Pl. I., Fig. 1, *c*), apparently associated with the pleural, are, in the type specimen, situated in an asymmetrical position, being placed on the right side of the pharynx. From this nerve mass connectives extend, on each side of the pharynx, to the pedal ganglia, large, closely appressed groups of nerve cells placed symmetrically with reference to the mid ventral line. The cerebral ganglia likewise originate buccal connectives that, extending along the pharynx, unite with ganglia imbedded in the salivary glands on the dorsal and ventral side. The buccal ganglia are further united by two commissures that form a collar about the pharynx. In the neighborhood of the opening of the reproductive system into the pseudopallium there is a large ganglion, probably the visceral.

that gives off a strong nerve which may be traced a short distance posteriorly, and in the opposite direction a single connective leads from it to the cerebro-pleural ganglia, as indicated in Pl. I., Fig. 1, *v*. At various points throughout the body it is possible to discover nerve bundles, but in every case it has been impossible to determine their origin.

In the three animals examined there is no sign of a testis, though the seminal receptacle of one individual contains a considerable number of spermatozoa. These last named elements possess almost spherical heads measuring approximately 0.004 mm. in diameter. Nuclei of somewhat similar appearance may be detected here and there in the follicles of the reproductive gland, but their close resemblance to those of the connective tissue cells renders the determination uncertain. If self-fertilization does not occur in this species it is difficult to understand the method of sperm transfer especially in those examples where but one parasite occurs in the host which completely envelops it.

The ovary, occupying fully half of the visceral mass, consists of a large number of follicles united directly or indirectly with the duct leading to the exterior. In a mature condition the central portions of each follicle are packed with fully developed ova, while numerous cells in the earlier stages of formation bound the periphery. About the center of the visceral mass the common chamber, communicating with the ovarian follicles, narrows anteriorly and the short resulting tube, after a somewhat twisted course, unites (elliptical stippled outline, Pl. I., Fig. 2) with the definite gonoduct leading to the exterior. This last-named canal consists of three divisions corresponding to the albumen and mucous glands and the seminal receptacle in other species of gastropods. The canal from the ovary unites with the albumen gland which extends posteriorly as a pouch of considerable size. Its walls are relatively thick, and are fashioned into a few prominent folds, consisting of relatively slender cells, whose vacuolated secretion stains lightly with Delafield's hæmatoxylin. Slightly anterior to the oviduct connection, a cone-shaped seminal receptacle (Pl. I., Fig. 2, *r*) is attached to the albumen secreting section. Its epithelial lining is developed into a large number of folds between which there are quantities of spermatozoa, that

likewise occupy the main lumen and even extend in small quantities some distance into the albumen gland. Anterior to the seminal receptacle the walls of the canal change abruptly, becoming thicker and the secretion stains so intensely that the cell outlines and nuclei become almost completely obliterated. This state of affairs exists between the seminal receptacle and a point slightly posterior to the external reproductive opening. Anterior to this region the duct presents the form of a roughly conical sac extending to a point opposite the foot. The walls of this pouch are similar to the darkly staining ones just described save that the secretion is more vacuolated and accordingly less deeply stained. The duct leading from this mucous secreting, main canal to the exterior is relatively short, thin-walled and passes into the furrow at the right side of the body formed by the union of the visceral mass with the pseudopallium.

In two specimens whose pseudopallium contained fully 500 embryos the ovary held an equal number of ova in a fully developed condition. Hence it is probable that during adult life the brood pouch is empty for short periods only.

The genus may be defined as follows:

Asterophila new genus. Body globular, 2-20 mm. in diameter, completely enveloped in the pseudopallium. Foot and mantle rudimentary. Buccal-pharyngeal tube, with salivary glands, opens into combined stomach and digestive gland that otherwise do not open to the exterior. No radula. Albumen and mucous glands on reproductive canal highly developed, and seminal receptacle prominent. Parasitic in starfish *Pedicellaster* sp., Sea of Japan. Type of genus *A. japonica*.

A. japonica new species. With characters of the genus.

EXPLANATION OF FIGURES.

PLATE I.

FIG. 1. Diagrammatic view of *Asterophila japonica*, left side, with the greater portion of the pseudopallium removed. *a*, albumen gland; *c*, cerebral ganglion; *f*, papilla-like foot; *g*, mantle fold; *l*, digestive gland or liver; *m*, mucous gland; *ov*, ovary; *p*, buccal tube and pharynx with salivary glands, buccal ganglia, connectives and commissures; *r*, seminal receptacle under which is dotted outline of duct from ovary; *ur*, urino-genital opening; *v*, visceral ganglion.

FIG. 2. Diagram of anterior surface. *e*, *e'*, openings of reproductive and excretory systems into pseudopallial space; *g*, mantle fold, the depth of the mantle cavity indicated by broken line; *h*, heart; *n*, kidney; *p*, buccal tube; *r*, seminal receptacle.

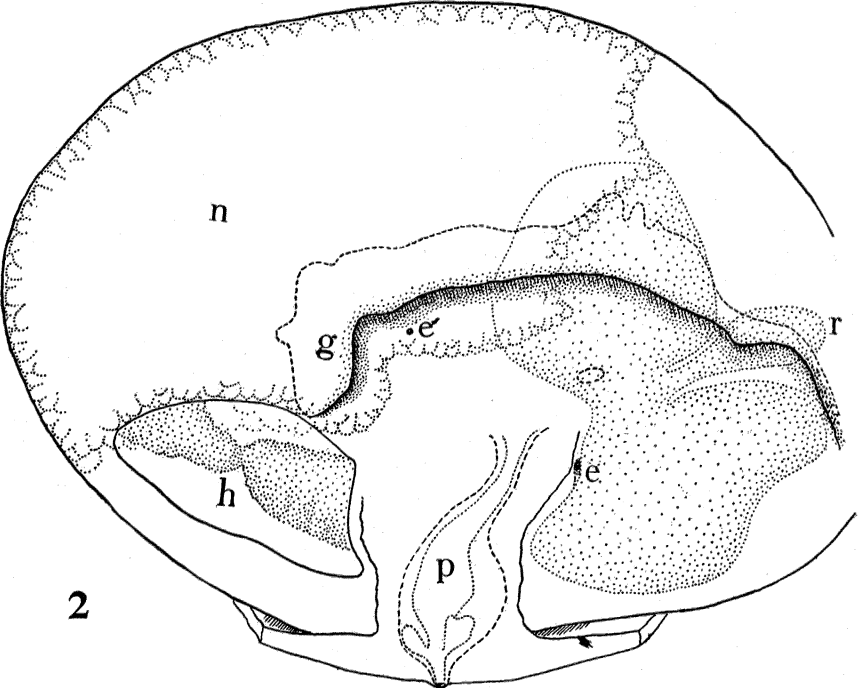
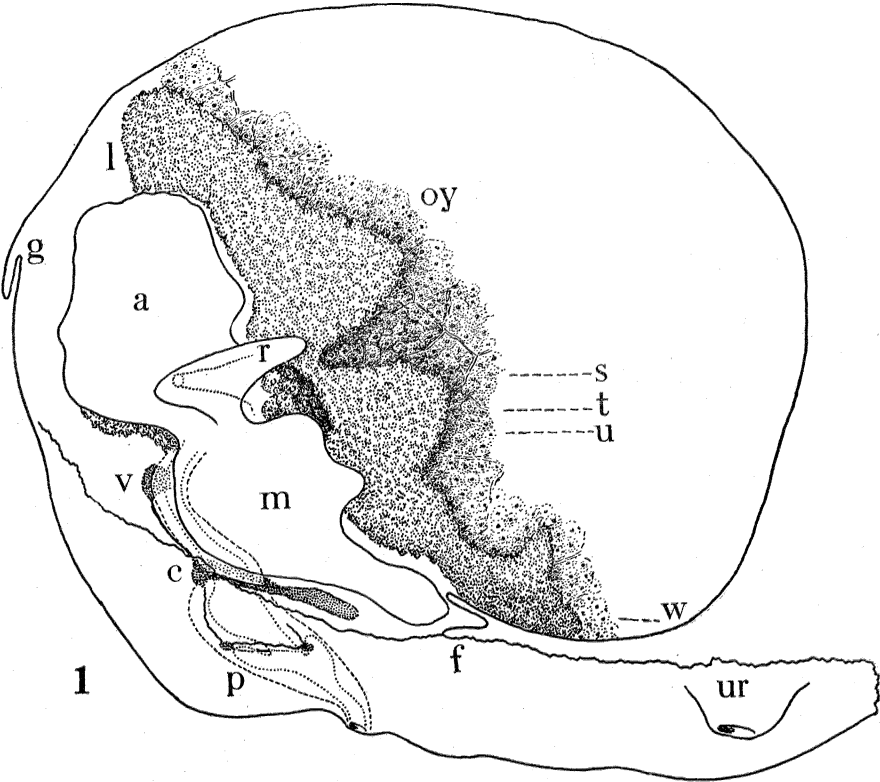


PLATE II.

FIG. 1. Anterior view of *Asterophila japonica* with pseudopallium partially removed.

FIG. 2. Arm of starfish containing parasite.

FIG. 3. Section through pharyngeal tube, showing salivary glands, buccal ganglia and surrounding head sinus.

FIG. 4. Section through foot and visceral mass; along line *w* of Pl. I., Fig. 1.

FIG. 5. Section along line *u*, Pl. I., Fig. 1; the junction of the œsophagus and stomach-intestine marked by an arrow.

FIG. 6. Section along line *t*, Pl. I., Fig. 1.

FIG. 7. Same along line *s*, Pl. I., Fig. 1.

FIG. 8. Diagram illustrating growth of pseudopallium in *Asterophila*.

FIG. 9. Same, *Clenosculum hawaiiense*.

